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(54) **Hydraulic circuit for a hydraulic cylinder**

Hydraulikkreis für einen Hydraulikzylinder

Circuit hydraulique d'un vérin hydraulique

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(73) Proprietor: **Caterpillar Work Tools B. V.**
5232 BJ 's-Hertogenbosch (NL)

(72) Inventors:
- **Luyendijk, Dirk Jacobus**
  5473 RE HEESWIJK-DINTHER (NL)
- **Van Gemert, Johannes Lambertus Leonardus**
  5451 BT MILL (NL)
- **Grant, Patrick**
  5045 TILBURG (NL)

(74) Representative: **BRP Renaud & Partner mbB**
Rechtsanwälte Patentanwälte
Steuerberater
Königstraße 28
70173 Stuttgart (DE)

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Description

Technical Field

[0001] This disclosure relates to a hydraulic apparatus for operation of a piston/cylinder assembly such as a dual acting hydraulic cylinder and to a method of cyclically operating a dual acting hydraulic cylinder. More particularly, this disclosure relates to cyclic operation of a dual acting hydraulic cylinder in a demolition machine.

Background

[0002] A hydraulic cylinder is a mechanical actuator which may be used to give a linear force. The hydraulic cylinder may have varied applications and may be used in vehicles and machines for example a demolition tool, which comprises of a jaw set that may be opened and closed by actuation of a hydraulic cylinder.

[0003] Hydraulic pressure from a pressurised fluid, such as oil, acts on the piston to perform linear work. Pressurised fluid may flow between a reservoir and the piston side or rod side chambers of the hydraulic cylinder for cyclic operation thereof. Generally, flow of pressurised oil into the piston side chamber may effect an extraction of the piston rod while flow of pressurised oil into the rod side chamber may effect retraction of the piston rod. Cycle time to extract or retract the piston rod may be dependent on multiple factors such as size of the cylinder. In certain engineering activities a reduction of the cycle time may be desired.

[0004] The cycle time of a hydraulic cylinder may be reduced by use of a speed valve or a regeneration valve.

[0005] US Patent No. 5996465 describes an oil-pressure cylinder in a crushing device connected to a crushing jaw to actuate the crushing jaw. Cylinder extension may cause the crushing jaw to close and crush an object. During a jaw closing stroke as the crushing jaw starts to close, to the point the crushing jaw comes into contact with the object, an acceleration (speed or regeneration valve) valve may make a continuous communication between a base-side port and a rod-side port in the cylinder. Oil from the rod-side port may be made to flow to the base-side port which may increase the movement-speed of the rod in the jaw closing stroke during the unloaded interval. When the crushing jaw comes into contact with the object, communication of the base-side port to the rod-side port is interrupted.

[0006] US Patent No. 7540231 describes a control valve device for the control of a dual-action consumer. A regeneration function allows the return side of the consumer to be connected with the admission side of the consumer. For the regeneration function, the connection of an additional pressure fluid line that forms the return side of the consumer with the reservoir can be blocked by a shutoff valve device located between the consumer and the control valve. The regeneration function may be overridden by an actuation of the shutoff valve device toward the open position as a function of the admission pressure at the admission side of the consumer. Under operating conditions wherein a high admission pressure is necessary to achieve high output power or increased performance, the regeneration function may be deactivated by the overriding of the regeneration function to ensure that the regeneration function is active only to achieve an increased speed of movement of the consumer.

[0007] Although the time to extract the piston rod may be increased, the aforementioned speed valves have a disadvantage in that the time to retract the piston rod is relatively long.

[0008] US Patent No. 5542180 describes a heavy duty shear comprising a fixed lower jaw and a movable upper jaw driven by a hydraulic cylinder. To overcome jams, the hydraulic cylinder is provided with an intensifier which pressurises a portion of hydraulic fluid above the maximum pressure of the machine hydraulic system. The hydraulic fluid at a higher pressure is provided to the cylinder to facilitate opening of the jaws. The output pressure of the intensifier is selected to overcome the difference in the area at the rod side of the piston and area at the piston side of the piston. The high pressure to open the jaw may be present only when a jam is to be cleared.

[0009] US 5415076 describes fluid regeneration circuits which may be useful for filling expanding sides of a hydraulic cylinder with fluid being exhausted from the other side. A flow regeneration valve and a pressure boost valve may be used in combination with a meter-out valve for providing flow regeneration from the head end chamber to a rod end chamber when fluid pressure in the head end chamber is less than the pressure level of fluid in a passage as determined by a spring of the pressure boost valve. The pressure boost valve may be disposed within the passage and may be oriented to block fluid flow from the exhaust conduit to the inlet of the meter-out valve. The boost valve is biased to the closed position by the spring to block fluid flow from the inlet to the exhaust conduit until the fluid pressure in the inlet exceeds a predetermined level.

[0010] The pressure boost valve may be involved with control of fluid flowing to the tank and may not be involved in improving cycle time of the hydraulic cylinder.

[0011] EP 09178089.0, in the name of Caterpillar Work Tools B.V., discloses a hydraulic device for operating a dual acting hydraulic cylinder comprising a speed component arranged to return a hydraulic fluid from a rod-side chamber to a piston-side chamber of the cylinder at a start phase of cylinder extraction and a booster component arranged to increase the pressure of the fluid at an end phase of cylinder extraction.

[0012] A similar system is also known from WO2008/057289 A1.

[0013] The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of the prior art system.

Brief Summary of the Invention

[0014] In a first aspect, the present disclosure describes a hydraulic circuit for operating a dual acting hydraulic cylinder comprising a speed component comprising a regeneration valve arranged to return a hydraulic fluid from a rod-side chamber to a piston-side chamber of the cylinder at a start phase of cylinder extraction; and a booster component comprising a first pressure intensifier and a second pressure intensifier arranged in parallel to increase flow of fluid at an end phase of cylinder extraction.

[0015] In a second aspect, the present disclosure describes a method of operating a dual acting hydraulic cylinder, the method comprising the steps of: returning a hydraulic fluid from a rod-side chamber to a piston-side chamber of the cylinder during a start phase of cylinder extraction with a speed component; and increasing flow of fluid during end phase of cylinder extraction with a booster component comprising a first pressure intensifier and a second pressure intensifier arranged in parallel.

Brief Description of the Drawings

[0016] The foregoing and other features and advantages of the present disclosure will be more fully understood from the following description of various embodiments, when read together with the accompanying drawings, in which:

Fig. 1 is a schematic representation of a first embodiment of a hydraulic circuit according to the present disclosure coupled to a hydraulic cylinder;

Fig. 2 is a schematic representation of a second embodiment of the hydraulic circuit according to the present disclosure coupled to a hydraulic cylinder; and

Fig. 3 is a comparative graph of operation cycle times of jaw sets of demolition tools during a demolition application including the operation cycle time of a jaw set actuated by a hydraulic cylinder coupled to the hydraulic circuit according to the present disclosure.

Detailed Description

[0017] This disclosure generally relates to a hydraulic device **10** for operating a piston/ cylinder assembly such as a hydraulic cylinder, in particular a dual acting hydraulic cylinder.

[0018] Figure 1 shows a schematic representation of hydraulic connections between the hydraulic device **10** and a hydraulic cylinder **20** in a first embodiment. The hydraulic connections may be suitably provided for operation and control of the hydraulic device **10** and the hydraulic cylinder **20**. Operation of the hydraulic device **10** and the hydraulic cylinder **20** may be effected through pressurisation of the hydraulic fluid.

[0019] The hydraulic cylinder **20** may comprise of a piston-side chamber **22**, a rod-side chamber **24**, a rod **26**, a piston **28** and a cylinder body **30**. The hydraulic cylinder **20** may go through cylinder extraction or extraction stroke when the rod **26** moves out from cylinder body **30**. Cylinder retraction or retraction stroke may occur when the rod **26** moves into cylinder body **30**.

[0020] Hydraulic lines may be connected to the cylinder body **30** for passage of fluid into the piston-side chamber **22** and the rod-side chamber **24**. Line **44** may be connected to piston-side chamber **22**. Line **44** may permit flow of fluid to and from piston-side chamber **22**. Line **42** may be connected to the rod-side chamber **24**. Line **42** may permit flow of fluid to and from rod-side chamber **24**.

[0021] For cylinder retraction, the hydraulic fluid from a fluid reservoir **76** may be pumped to rod-side chamber **24** through line **43** and line **42** while fluid from the piston-side chamber **22** may be allowed to return to a fluid source **74** through the line **44** and line **45**.

[0022] In an embodiment, fluid reservoir **76** and fluid reservoir **74** may be the same.

[0023] For cylinder extraction, the hydraulic fluid may be pumped from the fluid source **74** to piston-side chamber **22** through line **45** and line **44** while fluid from the rod-side chamber **24** may be allowed to return to the fluid reservoir **76** through the line **42** and line43.

[0024] In an embodiment, at initiation of an operation cycle of the hydraulic circuit **10** the hydraulic cylinder **20** may be fully extracted. The jaws of a demolition device may be completely closed. The hydraulic cylinder **20** may be fully retracted at mid-cycle with the jaws of the demolition device being completely open. At the end of an operation cycle of the hydraulic circuit **10** the hydraulic cylinder **20** may be returned to the fully extracted position so that the jaws of the demolition device are returned to the completely closed position.

[0025] The hydraulic device **10** may comprise of a booster component **12**, a speed component **14** and a main valve **40**.

[0026] Main valve **40** may permit flow of fluid from the fluid source **74** and/ or the reservoir **76** to the hydraulic cylinder **20**. Main valve **40** may be connected to hydraulic cylinder **20** through lines **44** and **42**. Main valve **40** may permit fluid to flow between the hydraulic cylinder **20** and the fluid source **74** and/ or the reservoir **76** through lines **44** and **42**.

[0027] Main valve **40** may have an extraction flow position **19** and a retraction flow position **21**. At the extraction flow position **19** fluid may be permitted to flow from the fluid source **74** to line **44** and fluid may flow from line **42** to the fluid reservoir **76**. At the retraction flow position **21** fluid may be permitted to flow from the fluid reservoir **76** to line **42** and fluid may flow from line **44** to the fluid source **74**. The hydraulic cylinder **20** may operate under the normal extraction function with the main valve at the extraction flow position **19**. The hydraulic cylinder **20** may be under the normal extraction mode when the extraction flow position **19** is selected.

[0028] The booster component **12** and the speed component **14** may also comprise sequence valves **50, 52** for pressure controlled activation or deactivation of the components. In an embodiment, the hydraulic connections may be arranged to activate or deactivate the booster component **12** and the speed component **14** in sequence. The hydraulic cylinder **20** may be under the speed mode when the speed component **14** is activated and may be under the boost mode when the booster component **12** is activated.

[0029] The speed component **14** may comprise of a regeneration valve. In an embodiment, the regeneration valve **18** may be comprised within the main valve **40**.

[0030] Main valve **40** may further comprise a regeneration position **23**. Main valve 40 may be actuatable between the extraction flow position **19**, the retraction flow position **21** and the regeneration position **23**.

[0031] The speed component **14** may be arranged to be activated during the extraction stroke of the cylinder **20**. The main valve **40** may be at the regeneration position **23**. The speed component may be activated upon flow of hydraulic fluid into line **44**.

[0032] At the regeneration position **23** the regeneration valve **18** may permit fluid to flow from the fluid source **74** to the piston-side chamber **22** and may divert fluid flowing from the rod-side chamber **24** to the piston-side chamber **22**. The regeneration valve **18** may be active at the regeneration position **23**. The regeneration function of hydraulic circuit **10** may be enabled at the regeneration position **23**.

[0033] The main valve **40** may be actuatable under fluid pressure. Main valve **40** may be controlled through fluid pressure in lines **43** and **44**. A position of the main valve **40** may be selected or deselected by the fluid pressures in the lines **43** and **44**. A position of the main valve 40 may be selected or deselected by the difference in fluid pressures in the lines **43** and **44**.

[0034] In an embodiment, increase in pressure in line **44** may actuate the main valve **40** from the regeneration position **23** to the extraction flow position **19**. In an embodiment, increase in pressure in line **43** may actuate the main valve **24** from the extraction flow position **19** to the regeneration position **23**. Return springs associated with the main valve **40** may return the main valve to a previous position upon a decrease in fluid pressure.

[0035] The speed component **14** may be arranged to be deactivated during the extraction stroke if the hydraulic pressure acting on a sequence valve **52** exceeds a predetermined pressure. Thereafter, the speed component **14** may be arranged to be re-activated during the extraction stroke if the hydraulic pressure acting on sequence valve **52** falls below a predetermined pressure. In an embodiment, the activation and deactivation pressures of the sequence valve **52** in speed component **14** may be the same.

[0036] The booster component **12** may comprise of a first pressure intensifier **16** and a second pressure intensifier **17**. Booster component **12** may be connected to the piston-side chamber **22** of cylinder **20** through hydraulic line **44**.

[0037] The hydraulic circuit **10** may further comprise a control valve **32**. Booster component **12** may be controlled by a control valve **32**. Control valve **32** may control fluid pressures acting on the first pressure intensifier **16** and the second pressure intensifier **17**. Control valve **32** may be positioned on line **44**. Control valve **32** may control flow of fluid through line **44**.

[0038] Control valve **32** may be a two way valve having a first position **35** and a second position **36**. At first position **35** fluid may be permitted to flow directly to piston-side chamber **22**. At second position **36** fluid may be diverted to flow directly to first pressure intensifier **16** and second pressure intensifier **17** through line **37**. Line **37** may be connected though separate lines to first pressure intensifier **16** and second pressure intensifier **17**. Fluid from the first pressure intensifier **16** and second pressure intensifier **17** may flow though line **38** to line **44**. Line **38** may be connected though separate lines to first pressure intensifier **16** and second pressure intensifier **17**. Fluid from line **38** may enter line **44** downstream from the control valve **32**.

[0039] First pressure intensifier **16** may comprise a cylinder **80**. The cylinder **80** may have a first side piston **81** and a second side piston **83**. The first side piston **81** and the second side piston **83** may extend laterally from opposite ends of a central member **82**. The cylinder **80** may comprise a first cavity **84** and a second cavity **85**. First cavity **84** may accommodate the first side piston **81**. Second cavity **85** may accommodate second side piston **83**.

[0040] First cavity **84** may be connected to line **37** and second cavity **85** may be connected to line **38**.

[0041] Second pressure intensifier **17** may comprise a cylinder **90**. The cylinder **90** may have a first side piston **91** and a second side piston **93**. The first side piston **91** and the second side piston **93** may extend laterally from opposite ends of a central member **92**. The cylinder **90** may comprise a first cavity **94** and a second cavity **95**. First cavity **94** may accommodate the first side piston **91**. Second cavity **95** may accommodate second side piston **93**.

[0042] First cavity **94** may be connected to line **37** and second cavity **95** may be connected to line **38**.

[0043] The booster component **12** and the speed component **14** may be arranged to remain inactive during cylinder retraction regardless of the hydraulic pressure acting on sequence valves **50, 52**.

[0044] The booster component **12** may be arranged to be activated during the extraction stroke if pressure acting on sequence valve **50** exceeds a predetermined pressure and may be deactivated if the pressure acting on sequence valve **50** falls below a predetermined pressure.

[0045] In an embodiment the activation and deactivation pressures of the sequence valve **50** in the booster component **12** may be the same.

[0046] The control valve **24** may be actuatable by fluid pressure in line **44**. Increasing fluid pressure in line **44**

may actuate sequence valve **50** to permit fluid to flow for actuation of the control valve **32** from the first position **35** to the second position **36**. As fluid pressure decreases the sequence valve **50** may no longer permit flow of fluid to control valve **32**. The decrease of pressure acting on control valve **32** may permit a return spring associated with the control valve **32** to move the control valve **32** from the second position **36** to the first position **35**.

[0047] At initiation of the operation cycle of the hydraulic circuit **10** the hydraulic cylinder **20** may be fully extracted and the main valve **40** may be at the retraction position **21** to enable retraction of the hydraulic cylinder **20**.

[0048] As the hydraulic cylinder **20** is retracted the operation cycle may reach mid-cycle and the hydraulic cylinder **20** may be fully retracted.

[0049] As the operation cycle moves from mid-cycle to the end of the cycle, the main valve **40** may be actuated from the regeneration position **23** to the extraction position **19** to enable extraction of the cylinder **20**. The extraction position **19** may be selected when fluid pressure increases to a predetermined pressure level in line **44**.

[0050] As the pressure in line **44** increases further the booster component **12** may be activated through the actuation of the sequence valve **50** and the control valve **32**.

[0051] In an embodiment, the regeneration position **23** may be selected only once during an operation cycle. Subsequent to complete retraction of the hydraulic cylinder **20** main valve **40** may be actuated to the regeneration position **23**. After the actuation from regeneration position **23** to the extraction position **19** the regeneration position **23** may not be re-selected before end of the operation cycle of the hydraulic circuit **10**.

[0052] Figure 2 shows a schematic representation of hydraulic connections between the hydraulic circuit **10** and the hydraulic cylinder **20** in a second embodiment.

[0053] In the second embodiment, the speed component **14** and the main valve **40** may function as described in the first embodiment.

[0054] In the second embodiment, the booster component **12** may comprise the first pressure intensifier **16**, the second pressure intensifier **17**, the sequence valve **50**, a diversion valve **54** and an additional sequence valve **56**.

[0055] The first pressure intensifier **16** and the second pressure intensifier **17** may comprise features as described in the first embodiment. Line **37** may connect diversion valve **54** though separate lines to first pressure intensifier **16** and second pressure intensifier **17**. Fluid from the first pressure intensifier **16** and second pressure intensifier **17** may flow though line **38** to the diversion valve **54**. Line **38** may be connected though separate lines to first pressure intensifier **16** and second pressure intensifier **17**.

[0056] The booster component **12** may be arranged for activation and deactivation during both the extraction and the retraction stroke. The hydraulic device **10** may have additional hydraulic connections to the hydraulic cylinder **20**. Booster component **12** may be connected through hydraulic lines **42, 44** to both the piston-side chamber **22** and the rod-side chamber **24**. The booster component **12** may be connected to the hydraulic lines **42, 44** through a diversion valve **54**. The diversion valve **54** may be arranged to divert the flow of hydraulic fluid from either the piston-side chamber **22** or the rod-side chamber **24** of the hydraulic cylinder **20** through the booster component **12** in accordance with an extraction stroke or a retraction stroke.

[0057] The diversion valve **54** may be arranged to divert the flow of hydraulic fluid from the rod-side chamber **24** through the booster component **12** during retraction stroke. The diversion valve **54** may be arranged to divert the flow of hydraulic fluid from the piston-side chamber **22** through the booster component **12** during the extraction stroke.

[0058] For cylinder retraction, the main valve **40** may pump hydraulic fluid from the fluid reservoir **76** to rod-side chamber **24** through lines **42** and **43** while fluid from the piston-side chamber **22** may be allowed to return to the fluid source **74** through the lines **44** and **45.** The booster component **12** may be arranged to be activated during the retraction stroke if pressure acting on sequence valve **56** exceeds a predetermined pressure. The booster component **12** may be arranged to be deactivated during the retraction stoke if pressure acting on sequence valve **56** falls below a predetermined pressure. In an embodiment the activation and deactivation pressures of the sequence valve **56** in booster component **12** may be the same.

[0059] For cylinder extraction, the main valve **40** may pump hydraulic fluid from the fluid source **74** to piston-side chamber **22** through lines **44** and **45** while fluid from the rod-side chamber **24** may be allowed to return to the fluid reservoir **76** through the lines **42** and **43**. The booster component **12** may be arranged to be activated during the extraction stroke if pressure acting on sequence valve **50** exceeds a predetermined pressure and may be deactivated if the pressure acting on sequence valve **50** falls below a predetermined pressure. In an embodiment the activation and deactivation pressures of the sequence valve **50** in the booster component **12** may be the same.

[0060] The hydraulic circuit **10** may be provided with additional pressure intensifiers. The additional pressure intensifiers may be connected to the hydraulic circuit **10** between lines **37** and 38. The additional pressure intensifiers may be connected so that fluid flow is as described with reference to the first and second pressure intensifiers **16, 17**. In an embodiment, the hydraulic circuit **10** may comprise 3 or more booster components.

[0061] The hydraulic circuit **10** may engage the hydraulic cylinder **20** through an operation cycle thereof. A cycle of the hydraulic cylinder **20** may comprise of an extraction stroke and a retraction stroke. The retraction stroke of the hydraulic cylinder **20**, coupled to the hydraulic device **10**, may have a single phase with a high retraction speed.

The speed component **14** and the booster component **12** of the hydraulic device **10** may be inactive during the retraction stroke of the hydraulic cylinder **20**.

[0062] The general operation of the hydraulic circuit **10** may proceed as follows. The main valve **40** may be at the regeneration position **23** for the start of the extraction stroke. As the load increases, the main valve **40** may be switched to the extraction flow position **19**. The hydraulic circuit **10** may operate under the normal extraction mode and the cylinder **20** may extract at normal speed. As the load further increases, the control valve **32** may be activated so as to activate the booster component **12**. The hydraulic circuit **10** may operate under the booster mode. Under the booster mode the pressure in the cylinder **20** may increase above the pressure of the machine. Subsequently, after the work material has been crushed, the pressure may decrease and the control valve **32** may be deactivated. The deactivation of the control valve **32** may permit the hydraulic circuit **10** to return to either the normal extraction mode or the speed mode.

[0063] The operation of hydraulic circuit **10** may effect an operation of the hydraulic cylinder **20**. An operation cycle of the hydraulic cylinder **20** may comprise of an extraction stroke and a retraction stroke. The retraction stroke of the hydraulic cylinder **20** may have a single phase with a high retraction speed. The speed component **14** and the booster component **12** of the may not be selected during the retraction stroke of the hydraulic cylinder **20**. During the retraction stroke the hydraulic cylinder **20** may not be subject to a load. The main valve may be at the retraction flow position **21**.

[0064] In an embodiment, the booster component **12** may be activated during the retraction stroke, if a jam occurs during the stroke. Activation of the booster component **12** may decrease retraction speed.

[0065] In an embodiment, the hydraulic cylinder **20** may have a 3 phase extraction stroke when subjected to a load.

[0066] In the first phase, the regeneration position **23** may be selected and booster component **12** may not be activated. The hydraulic cylinder **20** may be under the regeneration mode and may have a high extraction speed combined with low force output. During the first phase, the hydraulic cylinder **20** may not yet be subjected to the load.

[0067] In the second phase, the extraction flow position **19** may be selected and the booster component **12** may not yet be activated. Hydraulic cylinder **20** may have a medium extraction speed combined with a medium force output. During the second phase hydraulic cylinder **50** may be subjected to the load.

[0068] In the third phase, the booster component **12** may be activated while the main valve is at the extraction flow position **19**. The hydraulic cylinder **20** may have a low extraction speed and a high force output. During the third phase hydraulic cylinder **20** may be subjected to a higher load.

[0069] The respective times of each of the phase and sequence of the phases may be dependent on the load of the hydraulic cylinder **20**.

[0070] A 3 phase extraction may allow the hydraulic cylinder **20** to adapt suitably to requirements of a work application which may result in a more effective load cycle. Depending on the requirement of the work application the booster component **12** or the speed component **14** may be activated in order to provide sufficient closing speed or crushing force of a jaw set. The speed component **14** may be activated through the selection of the regeneration position **23** during cylinder extraction when no load is present. The booster component **12** may be selected during cylinder extraction when a higher crushing force is required. The switching capability allows for the right amount of force output to be provided as required by the momentary work requirement of the jaw set.

[0071] In certain work applications, the hydraulic circuit **10** may enable a 2 phase extension stroke of the hydraulic cylinder **20**, when subjected to a load, wherein the first phase is followed immediately by the third phase. A 2 phase extension stroke of the hydraulic cylinder **20** may occur when the hydraulic cylinder **20** is subjected to a very high load as soon as the jaw set contact the material to be worked.

[0072] The transition between the phases may occur as a function of pressure changes within the hydraulic circuit **10**. Hydraulic pressure within the hydraulic circuit **10** may effect activation of the speed component **14** or booster component **12** during the extraction stroke.

[0073] The hydraulic circuit **10** may provide for a short cycle time for a hydraulic cylinder **20** by decreasing the time needed for cylinder extraction. The hydraulic circuit **10** may increase fluid flow to the hydraulic cylinder **20** through the first and second pressure intensifiers **16, 17**. The output fluid flow of the first and second pressure intensifiers **16, 17** may reduce decrease the extraction time of hydraulic cylinder **20**.

[0074] Fig. 3 is a comparative graph of jaw set operation cycle times of demolition tools during a demolition application. The jaw set of the demolition tool may open to enable material to be introduced therein. To crush, cut, pulverise or otherwise work the material, the jaw set may close with the material contained therein.

[0075] The cycle time of the jaw set actuated by a hydraulic cylinder **20** coupled to an embodiment of the hydraulic circuit **10** is shown as line **306**. The cycle time of the jaw set actuated by a hydraulic cylinder coupled to a single booster component and a regeneration component shown as line **300**. The cycle time of a jaw set actuated by a hydraulic cylinder coupled to a booster component is shown as **302**. The cycle time of a jaw set actuated by a hydraulic cylinder coupled to a regeneration component is shown as line **304**.

i. Cylinder retraction

[0076] During cylinder retraction the jaw set of a demolition tool may move from a closed position to an open

position. The retraction flow position **21** may be selected in the main valve **40**. The booster component **12** and the speed component **14** may be inactive in the hydraulic circuit **10**. The hydraulic cylinder **20** may function as a standard dual acting cylinder. Hydraulic fluid may flow to the rod-side chamber **24** of the hydraulic cylinder **20** and pressure may be applied on the piston **28** at the rod-side chamber **24**.

[0077] The time for a jaw set of a demolition tool to fully open may be independent of a load presented by the material. The opening time may be dependent on the hydraulic cylinder and the components acting on the hydraulic cylinder. In Fig. 3 line **306** shows that the hydraulic cylinder **20** coupled to the hydraulic circuit **10** may be able to move from being fully closed (denoted by P_1) to fully open (denoted by P_2) in t_0-t_1 sec. Line **300** shows that the hydraulic cylinder coupled to the booster component and regeneration component may be able to move in the same time. Line **302** shows that the hydraulic cylinder coupled to the booster component may be able to move in the same time. Line **304** shows that the hydraulic cylinder coupled to the regeneration may be able to move from P_1 to P_2 in t_0-t_5 sec.

ii. Cylinder extraction (Start Phase)

[0078] During cylinder extraction the jaw set of a demolition tool may move from an open position to a closed position. The regeneration position **23** may be selected through actuation of the main valve **40**. The hydraulic cylinder **20** may operate under the regeneration function. Hydraulic fluid may flow to the piston-side chamber **22** of the hydraulic cylinder **20** and pressure may be applied on the piston **28** at the piston-side chamber **22**. Return flow of the hydraulic fluid from the rod-side chamber **24** may be redirected to the piston-side chamber **22** to increase velocity of cylinder extraction.

[0079] Return flow of the hydraulic fluid may be redirected as the hydraulic circuit **10** is subjected to a low to medium pressure. During this phase of cylinder extraction the jaw set which may contain the material to be worked, may not yet be subjected to the work load. As both jaws of a jaw set contact the material to be worked, the pressure in the hydraulic circuit **10** may spike (denoted by P_3).

[0080] The time for a jaw set of a demolition tool to move from P_2 to P_3 may be independent of a load of the material. The start phase time may be dependent on the hydraulic cylinder **20** and the components acting on the hydraulic cylinder **20**. In Fig. 3 line **306** shows that the hydraulic cylinder **20** coupled to the hydraulic circuit **10** may be able to move from P_2 to P_3 in t_1-t_2 sec.

[0081] Line **300** shows that the hydraulic cylinder coupled to the booster component and regeneration component may be able to move from P_2 to P_3 in the same time. Line **302** shows that the hydraulic cylinder coupled to the booster component may be able to move from P_2 to P_3 in t_1-t_3 sec. Line **304** shows that the hydraulic cylinder coupled to the speed component may be able to move from P_2 to P_3 in about t_5-t_6 sec.

iii. Cylinder extraction (Intermediate Phase)

[0082] The pressure in the hydraulic cylinder **20** may increase as the jaw set contacts the material. The hydraulic cylinder **20** coupled to the hydraulic device **10** may be under the normal extraction function.

[0083] During this phase of cylinder extraction the jaw set which may contain the material to be worked, may be subjected to the work load as the jaw set initiates work on the material.

[0084] The time for a jaw set of a demolition tool to move from P_3 (i.e. position of jaw at deselection of speed component **12**) to P_4 may be dependent on the load of the material, on the hydraulic cylinder **20** and the components acting on the hydraulic cylinder **20**. In Fig. 3 line **306** shows that the hydraulic cylinder **50** coupled to the hydraulic circuit **10** may be able to move from P_3 to P_4 in t_2-t_4 sec.

[0085] Line **300** shows that the hydraulic cylinder coupled to the booster component and regeneration component may be able to move from P_3 to P_4 in the same time. Line **302** and line **304** respectively show that the hydraulic cylinder coupled to the booster component and the hydraulic cylinder coupled to the speed component do not exhibit a phase 2 during cylinder extraction and instead transition directly from the start phase to the end phase.

iv. Cylinder extraction (End Phase)

[0086] The pressure in the hydraulic cylinder **20** may increase as the jaw set continues work on the material. At a predetermined pressure value, the booster component **12** may be activated. The hydraulic cylinder **20** coupled to the hydraulic circuit **10** may transition from operating under the normal extraction function to operating under the booster function.

[0087] Hydraulic fluid from the first and second pressure intensifiers **16, 17** may flow to the piston-side chamber **22** of the hydraulic cylinder **20** may be applied on the piston **28** at the piston-side chamber **22**. Return flow from the rod-side chamber **24** may be redirected to the fluid reservoir **76**.

[0088] During this phase of cylinder extraction the jaw set which may contain the material to be worked, may be subjected to the work load as the jaw set continues work on the material resulting in a further increase of pressure in the hydraulic circuit **10**. The pressure intensifiers **16, 17** may increase the closing force of the jaw set to a maximum level by increasing the pressure of the fluid flowing to the piston-side chamber **22**.

[0089] The time for a jaw set of a demolition tool to move from P_4 (i.e. position of jaw set at activation of pressure intensifiers **16, 17**) to P_1 (i.e. fully closed position of jaw set) may be dependent on the load of the material, on the hydraulic cylinder **20** and the components acting

on the hydraulic cylinder **20**. In Fig. 3 line **306** shows that the hydraulic cylinder **10** coupled to the hydraulic circuit **10** may be able to move from P_4 to P_1 in t_4-t_7 sec.

[0090] Line **300** shows that the hydraulic cylinder coupled to a single booster component and regeneration component may be able to move from P_4 to P_1 in t_4-t_8 sec. Line **302** and line **304** respectively show that the hydraulic cylinder coupled to the booster valve and the hydraulic cylinder coupled to the speed valve transition directly from the start phase to the end phase. Line **302** shows that the hydraulic cylinder coupled to the booster valve may be able to move from P_3 to P_1 in t_3-t_{10} sec. Line **304** shows that the hydraulic cylinder coupled to the speed valve may be able to move from P_3 to P_1 in about t_6-t_9 sec.

[0091] Fig. 3 indicates that the overall cycle time of line **306** is shorter than the respective cycle times of lines **300, 302** and **304**. Hence, the jaw set actuated by a hydraulic cylinder **20** coupled to the hydraulic circuit **10** may be able to open and close faster than jaws actuated by hydraulic cylinders coupled to a booster component or a speed component; or both a booster component and a speed component. The hydraulic cylinder **20** coupled to the hydraulic circuit **10** may require about half the time to open and close the jaw set compared to a hydraulic cylinder coupled to a single booster component and regeneration component. The time taken by hydraulic cylinder **20** coupled to the hydraulic circuit **10** may decrease to one third with three pressure intensifiers compared to a hydraulic cylinder coupled to a single booster component and regeneration component.

[0092] The skilled person would appreciate that foregoing embodiments may be modified or combined to obtain the hydraulic circuit **10** of the present disclosure.

Industrial Applicability

[0093] This disclosure describes a hydraulic circuit **10** for cyclically operating a dual acting hydraulic cylinder **20**.

[0094] In the operation of the hydraulic circuit **10** may be used to operate a dual acting hydraulic cylinder **20** that actuates a demolition tool. The hydraulic circuit **10** may be disposed within the demolition tool which incorporates the hydraulic cylinder **20**. The demolition tool may have a jaw set and may be used for crushing, cutting or pulverising material. The hydraulic circuit **10** may improve the opening and closing times of the jaw set.

[0095] The hydraulic circuit **10** may enable the jaws to open rapidly in the retraction stroke of the hydraulic cylinder **20**. Closing the jaw set in the extraction stroke of the hydraulic cylinder, the hydraulic circuit **10** may be actuated to the speed mode to enable the jaws to close at a faster rate, up to the point the jaws come into contact with material present in the jaws. Contact of the jaws with the material may result in a pressure spike in the hydraulic circuit **10** effecting a switch to the booster mode. In the boost mode a high pressure may be sent to the hydraulic cylinder **20** to increase the crushing, cutting or pulverising force of the jaw.

[0096] Switching of modes in the hydraulic circuit **10** may be dependent on the material to be worked. As an example of concrete as a material. The hydraulic circuit **10** may be initially in the speed mode upon contact with the concrete the hydraulic circuit **10** may be actuated immediately from the speed mode to the boost mode. In an alternative example with steel as a material, the hydraulic circuit **10** may be initially in the speed mode upon contact with the steel the hydraulic circuit **10** may remain in the speed mode. As the jaws of the demolition tool closes further the hydraulic circuit **10** may be actuated to the boost mode.

[0097] The hydraulic circuit **10** may comprise a booster component **14** having a first pressure intensifier **16** and a second pressure intensifier **17** in combination with a regeneration valve **18**. The pressure intensifiers may be arranged in parallel so that the maximum output pressure will not be higher than a circuit having a single pressure intensifier. The output flow may be doubled in comparison to a circuit having a single intensifier. Although the output is doubled, the material stress levels are not increased on the individual components. The output flow of each individual pressure intensifier may be collected through a hydraulic manifold and directed into the hydraulic cylinder **20**.

[0098] The hydraulic circuit **10** with the first and second pressure intensifiers **16, 17** may decrease the cycle time of a jaw set during normal operation. An advantage of the plurality of pressure intensifiers **16, 17** may be that each of pressure intensifier may have a smaller diameter cylinder rather than a single pressure intensifier having a large diameter cylinder which is required to have the same amount of fluid flow. Additionally, the working pressure of the jaw set with the plurality of pressure intensifiers **16, 17** may be substantially similar to the pressure of a single larger diameter cylinder.

[0099] Additionally, even with a failure of one pressure intensifier **16, 17** work operations may still continue with the remaining pressure intensifier **16, 17**.

[0100] Accordingly, this disclosure includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the disclosure unless otherwise indicated herein.

[0101] Where technical features mentioned in any claim are followed by references signs, the reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, neither the reference signs nor their absence have any limiting effect on the technical features as described above or on the scope of any claim elements.

[0102] One skilled in the art will realise the disclosure may be embodied in other specific forms without departing from the disclosure or essential characteristics thereof. The foregoing embodiments are therefore to be con-

sidered in all respects illustrative rather than limiting of the disclosure described herein. Scope of the invention is thus indicated by the appended claims, rather than the foregoing description, and all changes that come within the meaning and range of equivalence of the claims are therefore intended to be embraced therein.

Claims

1. A hydraulic circuit (10) for operating a dual acting hydraulic cylinder (20) comprising:

   a speed component (14) comprising a regeneration valve (18) arranged to return a hydraulic fluid from a rod-side chamber (24) to a piston-side chamber (22) of the cylinder (20) at a start phase of cylinder extraction; and
   a booster component (12) comprising a first pressure intensifier (16) and a second pressure intensifier (17) arranged in parallel to increase flow of fluid at an end phase of cylinder extraction.

2. The hydraulic circuit (10) of claim 1 further comprising a main valve (40) for control of fluid flow to the first pressure intensifier (16) and a second pressure intensifier (17) and the hydraulic cylinder (20).

3. The hydraulic circuit (10) of any one of preceding claims wherein the speed component (14), the first pressure intensifier (16) and the second pressure intensifier (17) are arranged to be inactive at an intermediate phase of cylinder extraction.

4. The hydraulic circuit (10) of any one of preceding claims comprising three pressure intensifiers.

5. The hydraulic circuit (10) of any one of preceding claims comprising a pressure actuated control valve (32) to divert fluid flow through the booster component (12).

6. A demolition tool comprising a hydraulic circuit (10) of any one of preceding claims.

7. A method of operating a dual acting hydraulic cylinder (20), the method comprising the steps of:

   returning a hydraulic fluid from a rod-side chamber (24) to a piston-side chamber (22) of the cylinder (20) during a start phase of cylinder extraction with a speed component (14) comprising a regeneration valve (18); and
   increasing flow of fluid during end phase of cylinder extraction with a booster component (12) comprising a first pressure intensifier (16) and a second pressure intensifier (17) arranged in parallel.

8. The method of claim 7 wherein the fluid pressure is increased at the rod-side chamber (24).

9. The method of claim 7 or 8 wherein step of increasing pressure of the fluid during end phase of cylinder extraction comprises increasing the fluid pressure at the piston-side chamber (22).

10. The method of claim 9 further comprising a step of returning fluid from the rod-side chamber (24) to a fluid reservoir (76) during an intermediate phase of cylinder extraction.

Patentansprüche

1. Eine hydraulische Schaltung (10) zur Betätigung eines doppeltwirkenden Hydraulikzylinders (20), die:

   eine Geschwindigkeitskomponente (14), die ein Regenerationsventil (18) enthält, die eingerichtet ist, um in der Startphase der Zylinderexktraktion eine Hydraulikflüssigkeit von einer stangeseitigen Kammer (24) in eine kolbenseitige Kammer (22) des Zylinders (20) zurückzuführen; und
   eine Druckerhöhungskomponente (12) umfasst, die einen ersten Drucübersetzer (16) und einen zweiten Drucübersetzer (17) umfasst, die parallel angeordnet sind, um die Durchflussrate eines Fluids in der Endphase der Zylinderextraktion zu verstärken,

2. Die hydraulische Schaltung (10) gemäß Anspruch 1, die weiterhin zur Kontrolle des Fluidflusses zum ersten Drucübersetzer (16) und zum zweiten Drucübersetzer (17) und dem Hydraulikzylinder (20) ein Hauptventil (40) umfasst.

3. Die hydraulische Schaltung (10) gemäß einem der vorhergehenden Ansprüche, wobei die Geschwindigkeitskomponente (14), der erste Drucübersetzer (16) und der zweite Drucübersetzer (17) so angeordnet sind, dass sie in einer Zwischenphase der Zylinderextraktion inaktiv sind.

4. Die hydraulische Schaltung (10) gemäß einem der vorhergehenden Ansprüche, die drei Drucübersetzer umfasst.

5. Die hydraulische Schaltung (10) gemäß einem der vorhergehenden Ansprüche, die ein druckbetriebenes Kontrollventil (32) umfasst, um den Fluidfluss durch die Druckerhöhungskomponente (12) zu leiten.

6. Ein Abbruchwerkzeug, das eine hydraulische Schaltung (10) gemäß einem der vorhergehenden Ansprüche, umfasst.

7. Ein Verfahren zum Betrieb eines doppeltwirkenden Hydraulikzylinders (20), wobei das Verfahren folgende Schritte umfasst:

   Zurückführen einer Hydraulikflüssigkeit von einer stangeseitigen Kammer (24) in eine kolbenseitige Kammer (22) des Zylinders (20) in der Startphase der Zylinderexktraktion mit einer Geschwindigkeitskomponente (14), die ein Regenerationsventil (18) umfasst, und
   Verstärkung des Fluidflusses in der Endphase der Zylinderextraktion mit einer Druckerhöhungskomponente (12), die einen ersten Druckübersetzer (16) und einen zweiten Druckübersetzer (17) umfasst, die parallel angeordnet sind.

8. Das Verfahren gemäß Anspruch 7, wobei der Fluiddruck in der stangeseitigen Kammer (24) verstärkt wird.

9. Das Verfahren gemäß Anspruch 7 oder 8, wobei der Schritt zur Verstärkung des Fluiddrucks während der Endphase der Zylinderextraktion eine Verstärkung des Fluiddrucks in der kolbenseitigen Kammer (22) umfasst.

10. Die Methode nach Anspruch 9, die den Schritt der Zurückführung eines Fluids von der stangeseitigen Kammer (24) in einen Fluidbehälter (76) in einer Zwischenphase der Zylinderexktraktion umfasst.

Revendications

1. Circuit hydraulique (10) pour mettre en oeuvre un vérin hydraulique à double action (20) comprenant :

   un composant de vitesse (14) comprenant une soupape de régénération (18) agencée pour renvoyer un fluide hydraulique depuis une chambre côté tige (24) vers une chambre côté piston (22) du vérin (20) à une phase de début d'extraction de vérin ; et
   un composant de suramplification (12) comprenant un premier intensificateur de pression (16) et un second intensificateur de pression (17) agencés parallèlement pour augmenter un flux de fluide au niveau d'une phase de fin d'extraction de vérin.

2. Circuit hydraulique (10) selon la revendication 1, comprenant en outre une soupape principale (40) pour commander un flux de fluide vers le premier intensificateur de pression (16) et un deuxième intensificateur de pression (17) et le vérin hydraulique (20).

3. Circuit hydraulique (10) selon n'importe laquelle des revendications précédentes dans lequel le composant de vitesse (14), le premier intensificateur de pression (16) et le deuxième intensificateur de pression (17) sont agencés pour être inactifs à une phase intermédiaire d'extraction de vérin.

4. Circuit hydraulique (10) selon n'importe laquelle des revendications précédentes comprenant trois intensificateurs de pression.

5. Circuit hydraulique (10) selon n'importe laquelle des revendications précédentes comprenant une soupape de commande actionnée par pression (32) pour détourner un flux de fluide à travers le composant de suramplification (12).

6. Outil de démolition comprenant un circuit hydraulique (10) selon n'importe laquelle des revendications précédentes.

7. Procédé de mise en oeuvre d'un vérin hydraulique à double action (20), le procédé comprenant les étapes de :

   renvoi d'un fluide hydraulique à partir d'une chambre côté tige (24) vers une chambre côté piston (22) du vérin (20) pendant une phase de début d'extraction de vérin avec un composant de vitesse (14) comprenant une soupape de régénération (18) ; et
   augmentation de flux de fluide pendant une phase de fin d'extraction de vérin avec un composant de suramplification (12) comprenant un premier intensificateur de pression (16) et un deuxième intensificateur de pression (17) agencés en parallèle.

8. Procédé selon la revendication 7 dans lequel la pression de fluide est augmentée au niveau de la chambre côté tige (24) .

9. Procédé selon la revendication 7 ou 8, dans lequel l'étape d'augmentation de pression du fluide pendant une phase de fin d'extraction de vérin comprend l'augmentation de la pression de fluide au niveau de la chambre côté piston (22).

10. Procédé selon la revendication 9, comprenant en outre une étape de renvoi de fluide depuis la chambre côté tige (24) jusqu'à un réservoir de fluide (76) pendant une phase intermédiaire d'extraction de vérin.

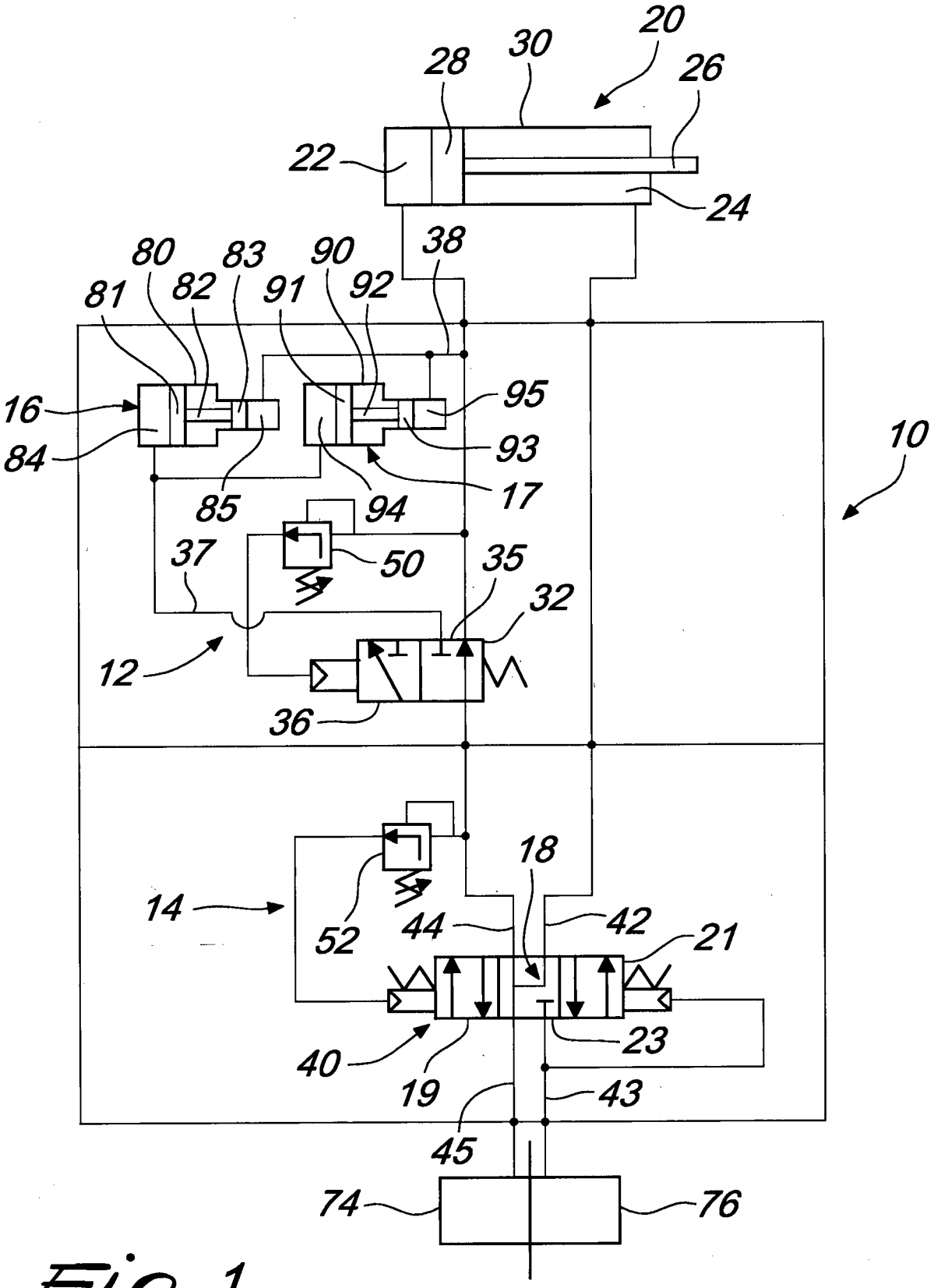
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Fig. 1

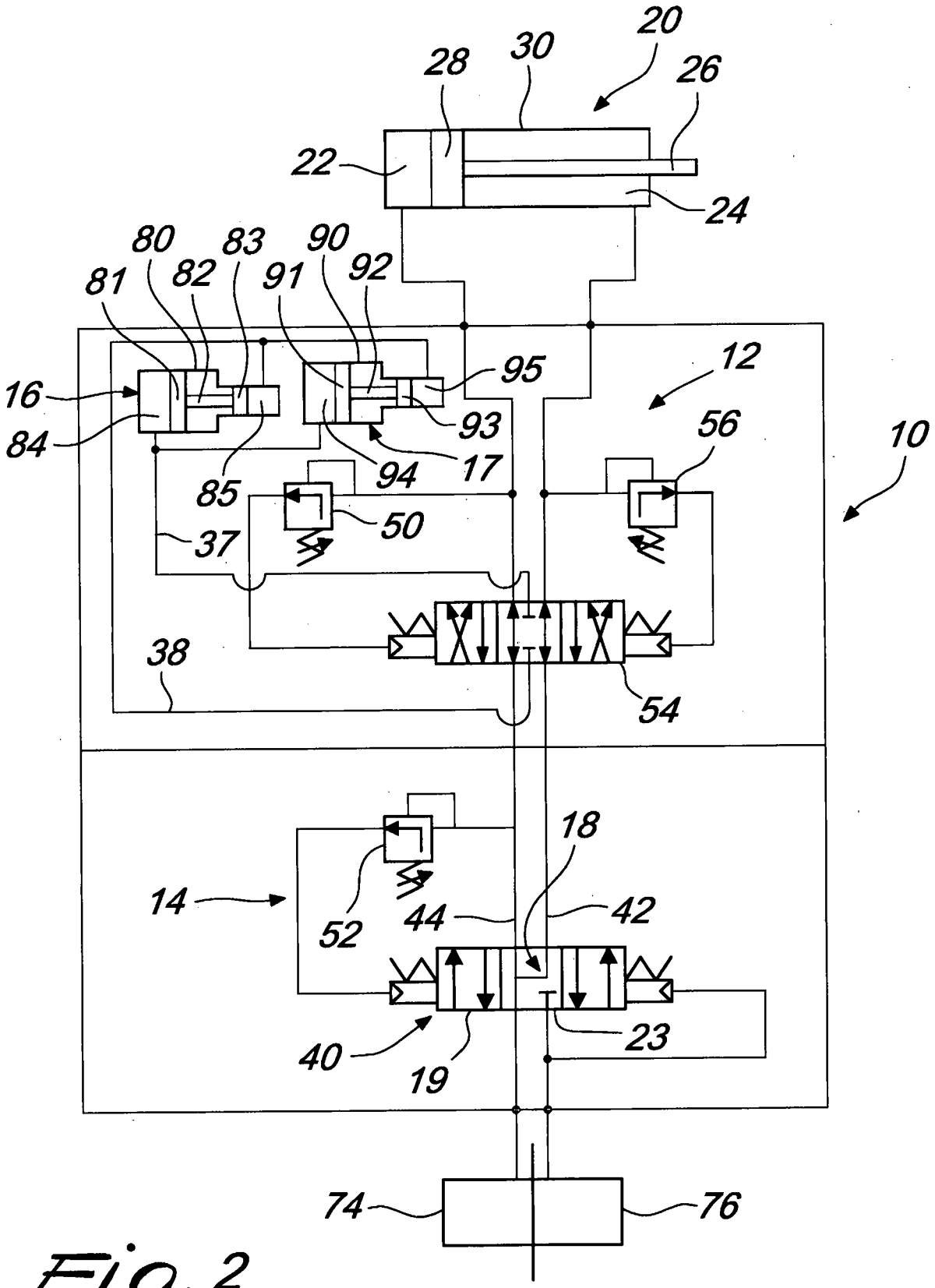
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Fig. 2

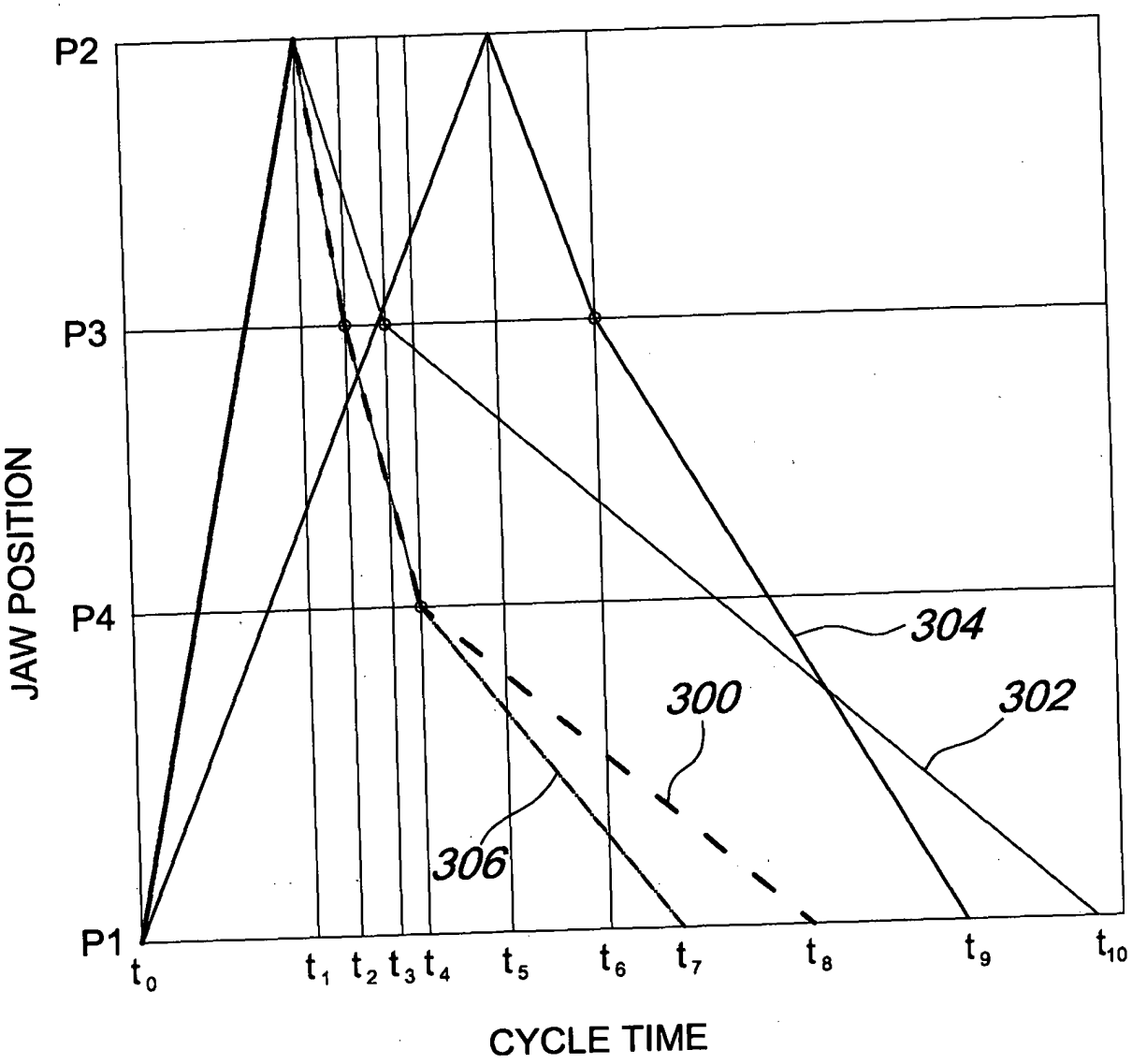
P2
P3
P4
P1
JAW POSITION
304
300
302
306
t_0
t_1
t_2
t_3
t_4
t_5
t_6
t_7
t_8
t_9
t_{10}
CYCLE TIME

Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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